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RECOGNITION AND INTERPRETATION OF PICTORIAL STIMULI FOUND WITHIN EDUCATIONAL STILL PICTURES.

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THE DISCRIMINATION OF PICTURES AND PICTURE ELEMENTS AMONG 5TH-, 8TH-, AND 11TH-GRADERS WAS STUDIED (1) TO DETERMINE THE DIFFERENCES IN INTERPRETATION OF SPECIFIC STATIC VISUAL STIMULI WHEN PRESENTED THROUGH TWO TYPES OF ILLUSTRATIONS (PHOTOGRAPHS AND OUTLINE DRAWINGS OF THE SAME SCENES) AND (2) TO GAIN INSIGHT INTO VARIATION IN THE INTERPRETATION OF THESE STIMULI. THE DEPENDENT VARIABLE IN THE STUDY WAS THE RESPONSE OF THE SUBJECT TO THE ILLUSTRATION. WITHIN THE SCOPE OF THE STUDY, LINE DRAWINGS AND PHOTOGRAPHS WERE EQUALLY EFFECTIVE IN OBTAINING CORRECT RECOGNITION AND INTERPRETATION OF STIMULI. PUPILS DEVELOPED SKILLS FOR INTERPRETING BOTH STIMULUS TYPES. RECOMMENDATIONS WERE MADE FOR FURTHER RESEARCH TO EXPAND THE KNOWLEDGE OF ILLUSTRATIONS USED IN THE SCHOOL. (JC)

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by

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A research project under the Cooperative Research Program of the U. S. Office of Education

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University Park, Pennsylvania

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INTRODUCTION

Illustrative material has been a part of man's efforts to preserve what he saw or did since before methods existed for translating experiences into a written language. With the perfection of writing, illustrative material became and remained for untold centuries supplementary to the verbal account. The last several generations, however, has seen a resurgence of illustrative material to the degree that they are frequently expected to carry the bulk of the message or serve as the primary basis for study and analysis.

In everyday life, the picture magazine has taken its place as a regular part of newsstand fare. Television has added the visual aspect to our perception of national and world events. Newspapers consider the photograph a standard part of their pages. And in our schools filmstrips, slides and illustrative display materials are fast becoming standard equipment for daily classroom activity. Textbooks and reference books use illustrative material in greater and greater profusion.

THE PROBLEM

Illustrations used in such contexts rest on an assumption that pictures add to knowledge and understanding. It presumes an understanding of the viewers reaction to various types of illustration -- from single line drawings to photographic fidelity. It requires that decisions be made regarding the elements included in or chosen to be a part of illustrations. It requires that, in choosing these elements, a prediction be made on the likely interpretation by the viewers. Yet,

research has not provided adequate information for making such judgments in the preparation of practical classroom illustrations.

Therefore, the purpose of this study is to investigate the way pupils identify elements of pictures and interpret the message contained in pictures as a step toward supporting decisions teachers must make when selecting illustrations for their classes.

OBJECTIVES

This study intends to explore this discrimination of pictures and picture elements among three age levels --fifth, eighth and eleventh graders. Pictures included are as similar as possible to study pictures normally found in classrooms. And finally the study deals only with two forms of pictorial illustration -- the photographic likeness of scenes or situations and outline drawings of the same scenes and situations. Two important objectives dominate this study. They are:

1. To determine the difference in interpretation of specific static visual stimuli when presented through two types of illustrations.
2. To gain insight into any variation in the interpretation of these stimuli among fifth, eighth and eleventh graders.

The dependent variable in this study is the response of the subject to the illustration provided -- his recognition of visual stimuli in the picture as well as his recognition of science concepts developed by these stimuli.

Null hypothesis applicable to the dependent variable in this investigation is:

1. There is no difference in results attributable to grade level among the illustrations.
2. There is no difference in results attributable to type of illustration (line drawing and photographic likeness).
3. There is no difference attributable to the interaction of type of illustration and grade level.

RELATED LITERATURE

Research in the use and perception of pictures, though not too extensive, has touched on numerous aspects of their application, some of which bear directly on this study. A majority of the investigations presently available can be classified under the heading of "Picture Preference Studies." These studies relate only in a general way to this study. Summaries of these experiments have been compiled by both Allen and Wendt & Butts.* More appropriate to this study are those research projects that deal with the interpretation of illustrative materials by the viewer. A short summary of related investigations are presented as background to this project.

*Allen, William H. "Audio-Visual Communication." Encyclopedia of Educational Research. New York: MacMillan Co., 1960, p. 115-37; and Wendt, Paul R. and Butts, Gordon K. "Audiovisual Materials." (Instructional Materials: Educational Media and Technology) Review of Educational Research. 32: 141-55; April 1962.

Miller studied the items seen by children in illustrations.* The relatively small quantitative recognition of items and the frequency on

*Miller, William A. "What Children See in Pictures." Elementary School Journal. 39: 280-88; 1938.

the part of the children of missing the most important items indicates the need for research to identify items most readily perceived. The study added emphasis to the basic question, how can the elements of static illustrations serve as elements for study (investigation and analysis) and for communication with the expectation of accurate interpretation on the part of the viewer?

Two studies conducted in the early fifties concerned themselves with a modified version of the above question. They grew out of the use of a verbal text having illustrative materials as accompaniment. The first of these by Vernon* used illustrations from known text ma-

*Vernon, M. D. "The Instruction of Children by Pictorial Illustrations." British Journal of Educational Psychology. 24: 171-79; 1954.

terials and combined them with condensed versions of the original text. Other subjects had illustrative material otherwise supplied (referred to by the experimenter as the "non-pictorial versions"), but with the same condensed text material. Her findings of "no significant differences" again raise the question of how pupils interpret the specific items in the illustrations? A further question might be deduced from her findings (or lack of them). What are appropriate items to be included in illustrations for children of that age group (eleven and twelve)?

The second of these studies, by Spaulding,* grew out of a Latin

*Spaulding, Seth. "Communication Potential of Pictorial Illustrations." Audio Visual Communication Review. 4: 31-46; 1956.

American project to produce text material with illustrations. Illustrations of various types were used with beginning adult readers. In

his summary (page 45) he lists three implications especially appropriate to the problems to be pursued in this study. First, illustrations ought to relate to, or be in some context with past experience of the viewer. Secondly, they should be kept simple in the number of items in an illustration, and in the number of actions demanded of the viewer and kept singular in possible interpretation. Finally, color added interest if it was realistic and functional.

Two further studies relate to a subquestion of the main problem of interpretation of illustrative material. What influence, if any, does the choice of subject content have on the recognition and interpretation of a specific picture and the specific stimuli found in it? Whipple attempted to identify themes and thematic characteristics which were important to children.* This laid some groundwork for a

*Whipple, Gertrude. "Appraisal of the Interest Appeal of Illustrations. Elementary School Journal. 53: 262-69; 1953.

later study by Bloomer in which he studied children's responses to themes as presented in pictures.* Children were asked to write a

*Bloomer, R. H. "Children's Preferences & Responses as Related to Styles and Themes of Illustration." Elementary School Journal. 60: 334-40; 1960.

story on the theme found in a picture. Of major concern here is his finding that children's preferences in pictures did not correlate with the completeness of stories written by the children from pictures. He concludes that stimulating qualities are more important criteria than whether or not the pictures are liked. This leads once again to the question of what elements will be effective in a picture?

Another study relates to the problem of interpretation of illus-

trations by the viewer. Tannenbaum and Fosdick set up a study to check the interpretation of subjects in pictures with different lighting on the principle person in the picture.*

*Tannenbaum, Percy H. & Fosdick, James A. "The Effect of Lighting Angle on the Judgment of Photographed Subjects." Audio Visual Comm. Review. 8: 253-62; 1960.

They found that in some cases lighting angle will influence the judgment of the subject of the picture by viewers. Unanswered questions of the influence of tonal quality of pictures and the like, points to the further need for research of the specific stimuli found in illustrations.

Four studies of recent years dealing with the perception of pictorial forms apply to the question at issue here. Zeigler and Leibowitz* studied the "apparent" size perceived by some children and adults.

*Zeigler, H. P. and Leibowitz, H. "Apparent Visual Size as a Function of Distance for Children and Adults." American Journal of Psychology. 70: 106-9; 1957.

By the use of simple wooden dowels that could be varied in length when extended more of less above covered floor stand they asked subjects to compare size with a predetermined length of dowel seen at a different angle. Adults, it appeared, had developed a more reliable estimate of size, particularly as the distance from the subject increased. They concluded that, in fact, this ability might well be a function of age.

Draguns and Multari used a technique of blurring pictures and used children from four different school grades to investigate judgments about such pictures. They found that "Consistent if small

differences among children in different grades suggested a tendency toward a greater amount of cue accumulation before making such judgments as a function of age and/or grade level. The number of errors on this task likewise declined at the higher grade levels."* Though

*Draguns, Juris G. & Multari, Guiseppi. "Recognition of Perceptually Ambiguous Stimuli in Grade School Children." Child Development. 32: 541-50: Sept. 1961.

by no means conclusive this study does raise the possible function of age as a part of interpretation and identification of parts of pictures.

Study pictures are seldom made up of single elements or visual stimuli. There is, more often than not, a dominant element or elements which are a part of a larger (if subordinate) field. Ghent explored some aspects of this problem by using overlapping and embedded figures with children of different ages.* In both phases of

*Ghent, L. "Perception of Overlapping and Embedding Figures by Children of Different Ages." American Journal of Psychology. 69: 575-87; 1956.

the experiment the number of figures omitted was relatively small. However, it was noted that omissions in both types of drawings decreased with age.

Age as a factor in perception and response is indicated by Kendler, Kendler and Learnard in their study on mediated responses to size and brightness of a pattern--in this case two squares, one black and the other white and in different sizes. At first, reward was given for "black" squares regardless of size. It was then changed to small squares regardless of brightness. Among other things, human development seemed to move from "...unmediated single-unit

S-R behavior..." to the mediated type of behavior.*

*Kendler, Tracy S., Kendler, Howard H. & Learnard, Beulay. "Mediated Responses to Size and Brightness as a Function of Age." American Journal of Psychology. 75: 571-87; 1962.

A more fundamental approach to the way pictures are perceived is explored at length by Hockberg in his article "The Psychophysics of Pictorial Perception."* Among other ideas discussed is the concept of

*Hockberg, Julian. "The Psychophysics of Pictorial Perception." Audio-Visual Communication Review. 10: 22-54, Sept.-Oct. 1962.

pictures as being made up of "edges" for the viewer. He feels that the question of "functional fidelity" then becomes an open area of inquiry. How much visual information is necessary for the viewer to properly interpret the stimulus?* Important to this discussion is his

*Ibid p. 30

conclusion about outline type drawings. "In short, outline-drawings are surrogates for edges, as are silhouettes."* Though not implicit

*Ibid p. 37

in these quotes there is the implication that "simple" surrogates (simple in specific structure, that is) provides more efficient stimuli for the viewer.

An area of investigation closely associated to the problems raised by Hockberg deals with the question of "realism" in a visual display and the problem of "compression of information." Robert M. W. Travers points out the application that might be made to the field of audio visual materials of the work already done in this field by such

people as Attneave and Colin Cherry.* After elaborating on the apparent limits of the nervous system to process complex patterns of visual stimuli Travers indicates the subsequent need for compressed messages for the receiver.

*Travers, Robert M. W., "The Transmission of Information to Human Receivers." Audio Visual Comm. Review. 12: 373-385, Winter 1964.

He concludes this phase of his discussion by saying, "The point being made here is that the emphasis on "realism" found in books on the design and use of audiovisual materials is the worship of a false god. The nervous system is not effective in dealing with the environment in all its wealth of detail. It handles it by simplifying it, and it is through such simplified imputs and the resulting perceptions and conceptualizations that man learns to cope with a very complex universe. Through providing simplified presentations of the environment in learning situations, the teacher can be sure that the compression process is effective."*

*Ibid p. 380

Only short comment need be made at this moment regarding this generalization. For those who may come to different conclusions than Travers, the question of redundancy and complexity is important. Beyond this point, it must be recognized that photographs can also be simplified. What might be at issue is the effectiveness of one type of edge--the photographic version--in communicating meaningful information as opposed to a less redundant, or better still less encumbered type of edge--the line drawing version.

In the writings of Travers, as in the studies quoted earlier the

structure of a stimulus needed for adequate recognition and interpretation has been discussed and investigated. Of necessity the concern has been "theoretical" to a degree. They are attempts to formulate a tenable basis for understanding human reaction to such surrogates. They do formulate some basis for questioning the recognition and interpretation of such surrogates by children in a learning situation.

One characteristic of pictures that are brought into a learning situation needs recognition. A picture or outline drawing brought into a classroom for study by pupils contains a combination of several or all of the elements refered to by the researchers discussed above. Furthermore, these stimulus-elements are combined in meaningful patterns that reach beyond the picture to the more total experiences of the pupil.

It has been noted that some still picture research deals with the way children see whole pictures. Out of their findings come continuing questions about the way people interpret pictures and the degree of recognition of specific pictorial elements by various age levels. Research has also produced findings which cast doubt on perference as the only or major factor determining the effectiveness of pictures.

Basic research in perception dealing with visual recognition points toward age as a varying factor in the ability to discriminate among elements of a picture. The inter-relation of age with the question of "functional fidelity" still needs further resolution. This study attempts to explore the compounding effects of these factors as they blend to make a coherent picture dealing with meaningful concepts in a school setting.

PROCEDURES

The basic purpose of this study, as has been indicated, was to compare the ways in which pupils "read" the contents of still pictures presented to them in two forms. Furthermore, it was intended to see if any differences in this reading ability might exist between pupils in various grade levels--specifically, the fifth, eighth and eleventh grades. The science area of the curriculum seemed appropriate for such a study.

In other words, this project required that a series of appropriate pictures be developed; that these ideas be executed in two versions, one photographic and the other a line drawing; that these should be checked carefully by knowledgeable people in science education and instructional media; and that these illustrations be tried out on a pilot group of subjects to determine the best method for obtaining manageable responses from the group of 300 subjects ultimately to be tested.

Developing Pictorial Stimuli

Selection of picture possibilities became the first task in developing this investigation. The following criteria governed the choosing of concepts for illustrations. It should be a valid science concept. It should be a concept commonly studied either before or during the grade levels involved in the study. It should contain elements of content appropriate to photographic and line drawing illustrations--e.g. visual in nature, clear in static presentation, presentable in both a photograph and in a line-drawing. It should need only one illustration to be complete. And it should involve elements

accessable in local science laboratories. Incidently, these same criteria governed selection of the final pictures from responses of the panel of science and media educators at a later date.

Science text books, commonly used in the fourth and fifth grades, the seventh and eighth grades, and the tenth and eleventh grades were explored in order to determine important areas of science study that might contain ideas for illustrations. From this exploration a list formed of areas studied by students in all of the grade levels mentioned above. This list appears in Appendix A.

At the time of this exploration, rough sketches were made of illustrations, drawings and photographs used by these text books as they related to the commonly studied areas of science. From this information specific picture possibilities were selected for use in this study. These picture possibilities were then sketched more carefully. Science consultants looked at these sketches and discussed their appropriateness as pictures and their relation to the science curriculum. Once it has been determined by these discussions that specific picture ideas had possibilities, more elaborate and specific sketches were made.

The photographer and a science educator studied the final sketches in order to bring together materials needed for the specific pictures. Several criteria guided the photographer, and later the graphic artist, when they created the two versions of the illustrations. They worked to maintain: simplicity of visual content structure appropriate to the concept, clarity of visual rendition appropriate to the medium, visual dominance of the chosen concept, and visual separation of the component stimuli compatible with this concept.

Thirty-nine picture ideas photographed as possible examples to be included in the final booklet were made into eight-by-ten, black and

white enlargements, and mounted in a notebook. A panel of five educators, three directly related to science education, and two with considerable experience in the use of various types of instructional media in educational situations reacted to these pictures. These educators stated their opinions of the pictures without being informed in advance of the specific scientific concept portrayed in each picture. They were told, however, that these pictures dealt with science. Appendix B indicates their reaction to the various pictures.

Out of this group of thirty-nine pictures, twenty-five were chosen to be used in the final booklets. Nineteen of the twenty-five pictures received a complete OK by all five panel members. Six of the twenty-five should be considered somewhat doubtful since they received either a question mark, a total rejection or perhaps both from one or two members of the panel. Not indicated in the skeleton outline of acceptance or rejection presented in the appendix is the enthusiastic approval by certain of the panel members of each of the five pictures chosen despite questionable reaction by other panel members. In view of their enthusiasm, it was decided to include these six pictures in the study, but to watch carefully for any difficulties that might arise during the testing of these pictures.

Once it has been determined which pictures would be used, a graphic artist reproduced these pictures in line drawing form. He very carefully made certain to use the same format and the same size relationships as appeared in the photograph. As can be seen in the comparative set of pictures in Appendix C the sketches very closely approximate the pictures. The photographer and artist expended every effort to provide the highest quality in each version. And it was further de-

termined that both the sketches and the photographs should be so produced that they used the most important characteristics of each medium to advantage in presenting the idea involved. When completed, these sketches were again presented to the panel of advisors, the science educators, for their criticism and their suggestions for improvements.

Pilot Group

Determining the test instrument to be used with the pictures in the final investigation was based upon the testing of a pilot group of students using both the photographs and the line drawings. A total of twenty students were involved in this pilot group, ten of them seeing the photographic versions of the scientific concepts, and ten seeing the line drawing version. The principal investigator showed the pilot subjects the pictures and asked them to respond to various questions similar to the ones finally decided upon for the written instrument--that is, what science ideas or concepts do you see and what things do you find in pictures that you can identify? Their responses and the questions of the investigator were recorded on a tape recorder and later transcribed by a secretary. It was hoped by this means to determine the best method of gaining reliable responses.

As a result of this experience the need to use the free response method of testing the subjects became evident. Original intentions were to use some form of objective question-answer method. However, it became obvious that questions of this type would lead the subject in responsing to the illustrations. Fortunately, in working with the pilot group, it also became obvious that a rating system could be devised which would simply indicate whether or not the youngsters saw

anything in the pictures and whether or not they recognized any kind of science concept. Furthermore, the simplicity of the pictures, containing a limited number of stimuli worked in favor of a manageable free response system.

As a result of this experience with the twenty students in the pilot group, a free response type of booklet was drawn up for the main group of subjects in the investigation. Two pages of this booklet, the instruction page and page 1 can be found in Appendix D. The other pages of the test booklet including up through picture No. 25 look exactly the same as Page 2, found in the appendix.

Rating Responses

The responses of the pilot group were used a second time as a means for checking the panel of experts who would ultimately rate the basic subjects of this investigation. The responses of the twenty students were retyped in a form which approximated the format of the answer sheet used for the major group. Among other things, all words spoken by this investigator that had been recorded and transcribed were removed from this version. This typed version of responses by the pilot group were then given to each of seven science teachers who had volunteered to help in the investigation.

They rated each of these responses on a special rate sheet without any knowledge as to the grade or the type of version that the students had seen. Criteria used by the judges when rating those responses and the 311 subjects later is contained in Appendix E. These rating sheets were then processed for an analysis of variance to determine if the judges were anywhere near each other in developing

their ideas about the responses.

The analysis of variance indicated that one of the judges, whom we will refer to here as No. 4, made his ratings somewhat higher than the other six judges. As a result of his judgements, several of the picture-responses appeared to be significantly different among the various judges. Therefore it was decided to re-run the information without including the ratings of judge No. 4. When this was done 18 of the pictures indicated that there was no significant difference among the ratings of the six remaining judges. Pictures No. 19 and 21 appeared with a significant difference at the five per cent level. Pictures number 4, 11, 17, 20, and 22 showed significant difference at the one per cent level.

Subjects Tested

Forty booklets of each version of the science illustrations were produced for use when gathering the principle data for this investigation. With the total of eighty booklets it was possible to service groups up to about 75 or 80 when so desired. Arrangements were made with the school system of a community of 40,000 population to test approximately 100 subjects in each of the 5th, 8th, and 11th grades. These pupils represented a cross section of the city and particularly of the school in which the investigation took place. Incidentally, the city receives its support from several large industries employing manual labor, highly skilled labor, and specialized professional personnel.

Subjects for the 5th grade groups came from an elementary school that had English classes where assignment to the class had been made by alphabetical order. It was possible to obtain 99 subjects from three such English classes representing approximately one-half of the

students in the fifth grade of that school. In order to maintain some type of a random order the pupils were allowed to sit wherever they wished when entering a cafeteria area. The booklets, which were numbered from 1 through 80, had been arranged in random order using a chart of random numbers. This random ordering of the test booklets were repeated for each group tested.

In the eleventh grade it was possible to test the pupils while they were in their home room where the assignment again resulted from alphabetical ordering. Thus, with the randomizing of the booklets it was possible to maintain a general randomization of the subjects and the two versions of pictures provided.

It was not as simple a situation when dealing with the junior high school involved. Here the pupils had already been arranged in homogeneous groupings. The eighth grade had eight classes to which pupils had been assigned. Three of these classes were generally considered as advanced learners. Three of the classes were considered as average learners. And two of the classes were considered to be slow learners. It was possible to compensate slightly for this variation by taking at random one class from each of the three categories. The class which arrived for the slow learners turned out to be somewhat smaller than the other two classes. This balanced somewhat the differences between the three groups.

The response booklets written by the pupils totaled 311--99 from the elementary school, 93 from the junior high school and the remainder from the high school.

These response booklets were then numbered arbitrarily from one through three hundred eleven. Using random numbers, they were again

arranged in a random order. When it was finally determined that there would be six judges, this tack of response booklets was then broken into six equal sized groups and given to the judges to be rated. Their ratings became the basis for the analysis which is to follow.

Statistical Procedures

To investigate the relationship of the type of illustration (picture) and grade level to the degree of understanding of the picture theme a two factor analysis of variance design was chosen. This method permitted the assessment of the statistical significance of (1) the association of different grade levels to degree of comprehension of the picture (2) the differences between understanding scores obtained for illustrations, line and photographs and (3) the interaction effect of grade level and type of picture on degree of comprehension of the illustration.

The number of observations in each of the nine cells was neither equal nor exactly proportionate, Table 1. Therefore, the general least squares procedure for fitting constants was utilized. The method of fitting constants serves to statistically "control". One of the independent or "treatment" variables (e.g. grade level) so as to permit the separate assessment of the relationship of the other "treatment" variable (picture type) to the dependent factor. Conversely, it provides for a statistical correction for the effect of picture type to permit separate evaluation of grade level.

Interaction was tested first. In cases where it was statistically significant at the .05 probability level, a weighted means analysis was used to adjust and test the significant of the main

effects.[1]

Table 1. Actual and Proportionate Expected Frequencies for the Sub-cells in the Sample.

Grade	Line		Photo		Total
	Actual Frequency	Proportionate Expected Frequency	Actual Frequency	Proportionate Expected Frequency	
5	43	47.59	57	52.41	100
8	47	43.78	45	48.22	92
11	58	56.63	61	62.37	111
	148		163		311

Descriptive tables showing the actual means for the sub-cells and adjusted means derived from the fitting constants procedure, for the total effect of grade level and of picture type were developed. The actual computational procedures were carried out by means of an IBM 7074 computer. The analysis of variance used library program ANOV2 (11.5.015) developed by Flora Chow of the Computation Center, Pennsylvania State University. The calculation of the unadjusted means was obtained from library program STATS (11.0.011) developed by G. W. Gorsline also of the Computatior Center, Pennsylvania State University.

Finally, a study of the results from the two factor analysis of variance indicated some possible value resulting from a simple analysis of variance of (1) illustrations--line and photographic--within specific grade levels (e.g. difference in comprehension between line

---

[1]See George W. Snedecor, Statistical Methods. Ames, Iowa: Iowa State College Press, 1946, 4th edition, pp. 296-301, for a more complete discussion of the method of fitting constants and the weighted means analysis.

and photographic subjects on the 5th grade level), and (2) differences between adjacent grade levels for a given version of illustration (e.g. difference between 5th and 8th graders in comprehending the line-version illustration). F-Ratio scores and significance for each illustration appears in lists in Appendix F and G. Data was obtained by the use of library program AOVD developed by Richard Craig of the Computation Center, Pennsylvania State University.

RESULTS

Differences that appeared among the three hundred eleven responses to twenty-five illustrations fall into three general groups. Subject responses to the largest group of illustrations with similar results indicated only a significant difference in age (as represented here by grade placement) with no significant difference appearing between the illustration versions nor any significant indication of an interaction between these elements. A smaller group of subjects displayed not only a grade difference but also a significant difference in the interaction factors operating in this investigation. Finally, two pictures received mixed statistical reaction including a statistically significant difference existing for picture type.

Closer study of the statistics for the twenty-five illustrations and their relationship to one another brings out several trends that appear deserving of mention in this report. In particular, different grades react differently to the two versions, even though there is not a large enough mean difference to be significant. Finally, a related trend within versions of illustrations developed which seems noteworthy of at least passing mention.

Grade Differences Only

The one area of consistent significant difference for the subjects in this investigation developed between the three grade levels used. Seventeen of the illustrations have F-ratios of some significance only relative to grade and no significance for either picture type or interaction. The statistics covering these illustrations are found in Tables 2 through 18.

Illustration #2

Table 2

Grade	Line $\bar{X}$	Line n	Photo $\bar{X}$	Photo n	Total Adjusted Mean	Total n
5	2.00	43	1.96	57	1.98	100
8	2.11	47	2.04	45	2.08	92
11	2.17	58	2.11	61	2.14	119
Total Adjusted Mean	2.09		2.04			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	2.37 n.s.
Age	2	7.95 sig. .001
Interaction	2	.06 n.s.

Table 3

Illustration #3

Grade	Line		Photo		Total Adjusted Mean	Total n
	$\bar{X}$	n	$\bar{X}$	n		
5	2.23	43	2.26	57	2.25	100
8	2.47	47	2.51	45	2.49	92
11	2.69	58	2.57	61	2.63	119
Total Adjusted Mean	2.47		2.45			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	.11 n.s.
Age	2	11.21 sig. .001
Ineraction	2	.61 n.s.

Table 4

Illustration #4

Grade	Line $\bar{X}$	Line n	Photo $\bar{X}$	Photo n	Total Adjusted Mean	Total n
5	2.19	43	2.14	57	2.16	100
8	2.32	47	2.56	45	2.44	92
11	2.50	58	2.41	61	2.45	119
Total Adjusted Mean	2.34		2.36			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	.11 n.s.
Age	2	8.97 sig. .01
Interaction	2	2.50 n.s.

Table 5

Illustration #5

Grade	Line		Photo		Total Adjusted Mean	Total n
	$\bar{X}$	n	$\bar{X}$	n		
5	2.09	43	1.93	57	2.01	100
8	2.06	47	2.07	45	2.06	92
11	2.22	58	2.13	61	2.18	119
Total Adjusted Mean	2.13		2.04			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	3.17 n.s.
Age	2	4.57 sig. .05
Interaction	2	.90 n.s.

Table 6

Illustration #8

Grade	Line $\bar{X}$	Line n	Photo $\bar{X}$	Photo n	Total Adjusted Mean	Total n
5	2,05	43	2.19	57	2.04	100
8	2.55	47	2.69	45	2.59	92
11	2.59	58	2.49	61	2.51	119
Total Adjusted Mean	2.33		2.44			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	2.55 n.s.
Age	2	23.82 sig. .01
Interaction	2	2.70 n.s.

Table 7

Illustration # 9

Grade	Line		Photo		Total Adjusted Mean	Total n
	$\bar{X}$	n	$\bar{X}$	n		
5	2.05	43	2.11	57	1.99	100
8	2.15	47	2.29	45	2.19	92
11	2.21	58	2.15	61	2.16	119
Total Adjusted Mean	2.07		2.16			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	1.93 n.s.
Age	2	3.32 sig. .05
Interaction	2	1.53 n.s.

Table 8

Illustration #10

Grade	Line $\bar{X}$	Line n	Photo $\bar{X}$	Photo n	Total Adjusted Mean	Total n
5	1.88	43	1.86	57	1.80	100
8	2.02	47	2.16	45	2.07	92
11	2.28	58	2.16	61	2.20	119
Total Adjusted Mean	2.00		2.04			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	.35 n.s.
Age	2	12.26 sig. .001
Interaction	2	.96 n.s.

Table 9

Illustration #12

Grade	Line		Photo		Total Adjusted Mean	Total n
	$\bar{X}$	n	$\bar{X}$	n		
5	1.88	43	1.96	57	1.86	100
8	2.11	47	2.29	45	2.18	92
11	2.16	58	2.11	61	2.12	119
Total Adjusted Mean	2.00		2.11			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	3.70 n.s.
Age	2	11.03 sig. .001
Interaction	2	1.46 n.s.

Table 10

Illustration #15

Grade	Line $\bar{X}$	Line n	Photo $\bar{X}$	Photo n	Total Adjusted Mean	Total n
5	1.19	43	1.32	57	1.21	100
8	2.15	47	2.04	45	2.08	92
11	2.34	58	2.05	61	2.17	119
Total Adjusted Mean	1.85		1.79			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	.46 n.s.
Age	2	46.61 sig. .001
Interaction	2	2.89 n.s.

Table 11

Illustration #16

Grade	Line $\bar{X}$	Line n	Photo $\bar{X}$	Photo n	Total Adjusted Mean	Total n
5	1.86	43	1.98	57	1.86	100
8	2.04	47	2.16	45	2.08	92
11	2.14	58	2.13	61	2.12	119
Total Adjusted Mean	1.96		2.08			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	3.71 n.s.
Age	2	7.17 sig. .001
Interaction	2	1.49 n.s.

Table 12

Illustration #17

Grade	Line $\bar{X}$	Line n	Photo $\bar{X}$	Photo n	Total Adjusted Mean	Total n
5	1.60	43	1.60	57	1.54	100
8	2.04	47	2.04	45	2.03	92
11	2.03	58	2.13	61	2.07	119
Total Adjusted Mean	1.84		1.92			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	1.28 n.s.
Age	2	23.38 sig. .001
Interaction	2	.44 n.s.

Table 13

Illustration #18

Grade	Line $\bar{X}$	Line n	Photo $\bar{X}$	Photo n	Total Adjusted Mean	Total n
5	1.88	43	2.04	57	1.88	100
8	2.13	47	2.18	45	2.13	92
11	2.22	58	2.20	61	2.19	119
Total Adjusted Mean	2.01		2.12			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	2.79 n.s.
Age	2	8.15 sig. .001
Interaction	2	2.69 n.s.

Table 14

Illustration #19

Grade	Line $\bar{X}$	Line n	Photo $\bar{X}$	Photo n	Total Adjusted Mean	Total n
5	1.70	43	1.89	57	1.75	100
8	2.11	47	2.24	45	2.15	92
11	2.21	58	2.05	61	2.10	119
Total Adjusted Mean	1.96		2.05			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	.99 n.s.
Age	2	8.05 sig. .001
Interaction	2	2.05 n.s.

Table 15

Illustration #20

Grade	Line $\bar{X}$	Line n	Photo $\bar{X}$	Photo n	Total Adjusted Mean	Total n
5	1.63	43	1.82	57	1.69	100
8	2.15	47	2.16	45	2.13	92
11	1.98	58	1.90	61	1.92	119
Total Adjusted Mean	1.88		1.95			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	.94 n.s.
Age	2	11.83 sig. .001
Interaction	2	2.66 n.s.

Table 16

Illustration #21

Grade	Line $\bar{X}$	Line n	Photo $\bar{X}$	Photo n	Total Adjusted Mean	Total n
5	1.88	43	1.84	57	1.78	100
8	2.19	47	2.18	45	2.16	92
11	2.83	58	2.15	61	2.21	119
Total Adjusted Mean	2.06		2.04			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	.06 n.s.
Age	2	10.31 sig. .001
Interaction	2	.95 n.s.

Table 17

Illustration #22

Grade	Line		Photo		Total Adjusted Mean	Total n
	$\bar{X}$	n	$\bar{X}$	n		
5	1.95	43	1.95	57	1.88	100
8	2.38	47	2.44	45	2.39	92
11	2.31	58	2.13	61	2.19	119
Total Adjusted Mean	2.15		2.16			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	.0052 n.s.
Age	2	13.22 sig. .001
Interaction	2	1.12 n.s.

Table 18

Illustration #24

Grade	Line $\bar{X}$	Line n	Photo $\bar{X}$	Photo n	Total Adjusted Mean	Total n
5	1.84	43	1.79	57	1.75	100
8	2.30	47	2.33	45	2.28	92
11	2.22	58	2.23	61	2.20	119
Total Adjusted Mean	2.06		2.10			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	.26 n.s.
Age	2	16.04 sig. .001
Interaction	2	.18 n.s.

It is interesting to note two illustrations had grade differences at the 5 per cent level, two illustrations at the one per cent level, whereas the remaining 13 illustrations were all significant at the .1 per cent level. Further mention of this particular tendency takes place later under "trends" and will be discussed in the "conclusions" section at greater length.

A review of the illustrations found in this category will quickly indicate that all areas of science are included in this larger group of seventeen pictures. The one possible exception has to do with Bernoulli's Principle, since the two pictures covering this area are found in the next two categories.

It should also be mentioned at this point, that similar grade differences exist for all of the pictures in each of the two categories reviewed in the subsequent sections of this report.

Mixed Grade and Interaction Differences

Interaction differences of a significant degree, characterize six of the illustrations making up the second category to be discussed. As has been indicated, these six illustrations also presented a significant grade difference consistent with the seventeen illustrations discussed above.

The six illustrations involved in this category are No. 1, No. 6, No. 7, No. 14, No. 3 and No. 25. Statistics relevent to these six illustrations can be found in Tables 19 through 24. The interaction factors present in these illustrations have F-ratios which are significant at the 5 per cent level or higher.

As will be noted later, the trend of differences between picture

Table 19

Illustration #1

Grade	Line $\bar{X}$	Line n	Photo $\bar{X}$	Photo n	Total Adjusted Mean	Total n
5	2.05	43	2.11	57	2.08	100
8	2.11	47	2.27	45	2.19	92
11	2.36	58	2.18	61	2.27	119
Total Adjusted Mean	2.17		2.18			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	.05 n.s.
Age	2	4.67 sig. .05
Interaction	2	3.77 sig. .05

Table 20

Illustration #6

Grade	Line		Photo		Total Adjusted Mean	Total
	$\bar{X}$	n	$\bar{X}$	n		
5	1.88	43	1.95	57	1.83	100
8	2.17	47	2.16	45	2.13	92
11	2.22	58	2.05	61	2.12	119
Total Adjusted Mean	2.03		2.03			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	.0006 n.s.
Age	2	8.79 sig. .001
Interaction	2	2.11 sig. .05

Table 21

Illustration #7

Grade	Line $\bar{X}$	Line n	Photo $\bar{X}$	Photo n	Total Adjusted Mean	Total n
5	1.98	43	2.12	57	1.97	100
8	2.02	47	2.13	45	2.06	92
11	2.24	58	2.07	61	2.14	119
Total Adjusted Mean	2.01		2.09			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	1.92 n.s.
Age	2	3.10 sig. .05
Interaction	2	5.57 sig. .01

Table 22

Illustration #14

Grade	Line		Photo		Total Adjusted Mean	Total n
	$\bar{X}$	n	$\bar{X}$	n		
5	1.81	43	1.93	57	1.79	100
8	2.02	47	2.09	45	2.04	92
11	2.07	58	1.97	61	2.00	119
Total Adjusted Mean	1.90		1.99			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	2.33 n.s.
Age	2	7.53 sig. .001
Interaction	2	3.42 sig. .05

Table 23

Illustration #23

Grade	Line $\bar{X}$	Line n	Photo $\bar{X}$	Photo n	Total Adjusted Mean	Total
5	1.40	43	1.60	57	1.44	100
8	1.98	47	1.87	45	1.90	92
11	1.93	58	1.92	61	1.91	119
Total Adjusted Mean	1.72		1.78			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	.83 n.s.
Age	2	21.38 sig. .001
Interaction	2	4.03 sig. .05

Table 24

Illustration #25

Grade	Line		Photo		Total Adjusted Mean	Total n
	$\bar{X}$	n	$\bar{X}$	n		
5	1.95	43	2.05	57	1.89	100
8	2.60	47	2.53	45	2.54	92
11	2.41	58	2.28	61	2.32	119
Total Adjusted Mean	2.23		2.27			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	.38 n.s.
Age	2	23.68 sig. .001
Interaction	2	3.36 sig. .05

types and the trend of differences between grade levels for these six illustrations are consistent with the major trends of the larger group of seventeen illustrations discussed earlier. Grade level differences on these illustrations exist at the 5 per cent level or greater for all of the six illustrations.

It is of some interest to note in passing the content of the six pictures involved in this particular group. To begin with, two of the pictures, No. 1 and No. 7, intended to portray the concept of leverage. Picture No. 6 might be said to have a concept in it which is only indicative of the outward actions that are apparent to the viewer, the actual principle itself not being visable. Interestingly enough, illustration No. 14, whose statistics are found on Table 22, is an effort to portray Bernoulli's Principle. Picture No. 23 whose statistics are found in Table 23, is a seldom seen cross section of a dry-cell battery. Although such pictures appear in many science texts, they do not resemble closely the actual photograph nor the drawing which was made of this cross section. This difference results from the fact that artists who normally draw cross sections of batteries take considerable liberties in their reproductions. Finally, picture No. 25 dealt with magnitism, a concept which appears in several other illustrations without any difficulty.

These illustrations displaying significant interaction between picture type and grade show a pattern of interaction that exists in a majority of the illustrations. Briefly, the means of line drawings progress constantly from the 5th grade to 8th grade to 11th grade, while means for the photographic versions increased from 5th to 8th

grade but developed a plateau or fell off from the 8th to the 11th grades. This tendency is dealt with more extensively later.

Mixed Picture Type and Grade Differences

The final category of illustrations contains only two pictures. They are illustration No. 11 found in Table 25 and illustration No. 13 found on Table 26. These two illustrations considerably differ in their statistical results from the other twenty-three illustrations used in the investigation. Both illustrations had a significant difference in picture type, one at the 5 per cent level and the other at the 1 per cent level. Illustration No. 11 also registered a grade difference at the .1 per cent level.

Several comments might be made about both picture No. 11 and picture No. 13. To begin with, picture No. 11 is again Bernoulli's Principle. However, this picture might also be interpreted as being just the reverse of Bernoulli's Principle as far as the action of the person in the picture is concerned. This could account for different interpretations both by the subjects and by the judges. It might be added at this point, that No. 11 was one of those on which the judges did register some significant difference in their original rating of the pilot group of responses.

Picture No. 13, though it appeared not to be questioned by the science educators who accepted its use, was questioned by one of the educators experienced with media with the comment that it might very well be interpreted as something other than a tomato. When interviewing the original pilot group many of the subjects read the picture to mean food of various types. This problem arose particularly for the

Table 25

Illustration #11

Grade	Line		Photo		Total Adjusted Mean	Total n
	$\bar{X}$	n	$\bar{X}$	n		
5	1.58	43	1.84	57	1.65	100
8	1.72	47	2.22	45	1.95	92
11	2.10	58	2.20	61	2.13	119
Total Adjusted Mean	1.75		2.06			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	18.98 sig. .001
Age	2	16.09 sig. .001
Interaction	2	2.13 n.s.

Table 26

Illustration #13

Grade	Line		Photo		Total Adjusted Mean	Total n
	$\bar{X}$	n	$\bar{X}$	n		
5	1.84	43	1.93	57	1.79	100
8	1.91	47	1.98	45	1.94	92
11	1.91	58	1.98	61	1.93	119
Total Adjusted Mean	1.81		1.96			
Total n		148		163		

	d.f.	F-ratio
Picture Type	1	4.09 sig. .05
Age	2	2.51 n.s.
Interaction	2	1.63 n.s.

line-version.

Finally it is interesting to note that illustration No. 13 produced similar trends of development for both the line and photograph in the statistics found on Table 26.

Trends

Several trends appear when one studies the statistics of all of the illustrations used. Two of these trends will receive comment before going on to the conclusions of this report. One of these trends deals with a comparison of the two versions of illustrations relative to the grade of the subjects reading the illustrations. The other deals with the trend of development from grade to grade within the line version and within the photographic version of the illustrations.

Of course, it must be realized that these are only trends with the mildest of support relative to some significant increases between age levels and on a few of the illustrations between versions. Since they do seem to indicate a trend worth future consideration, they are being included here.

A comparison of the photographic version and the line version of illustrations by the grades tested is found in Table 27. As can be seen from this table, the means of nineteen photographic versions are equal or higher than its line-version counterpart for the 5th grade. The same is true for the 8th grade. However, for the 11th grade twenty-one line-versions of the illustrations are higher than their photographic counterpart.

This trend has some mild support in the analysis mentioned earlier of the line versus photo at each of the grade levels using a sim-

ple analysis of variance. It was found that picture No. 5 and picture No. 11 were significantly different at the 5 per cent level. It is interesting to note that picture No. 5 has its significant difference in favor of the line-drawing version whereas picture No. 11 is in favor of the photographic version.

Table 27

COMPARISON OF PHOTO AND LINE VERSION BY GRADE

Mean Comparison	Fifth Grade	Eighth Grade	Eleventh Grade
Means for Line Version are Higher than Photo Version	6	6	21
Means of Line Version and Photo Version are Equal	2	1	
Means of Photo Version are Higher than Line Version	17	18	4

Table 28

TRENDS IN PHOTO AND LINE VERSIONS

Trend	Line Version	Photo Version
Means go up Constantly 5th, 8th, and 11th grade	18	8
Means go up from 5th to 8th grades but remain constant or go down from 8th to 11th grade	7	17

Analysis of the differences of the two versions in the 8th grade indicates that picture No. 4 is significantly higher in favor of the photographic version at the 5 per cent level whereas picture No. 11 is significantly different in favor of the photographic version at the 1 per cent level. At the 11th grade the significance has been reversed

and picture No. 1, picture No. 7 and picture No. 15 are all significantly different in favor of the line-version at the 5 per cent level.

More interesting than the previous trend, perhaps, is the difference in tendencies of the means within the photographic version and within the line versions. This trend can be easily seen by looking at Table 28. Note that the means go up constantly for the line-version in eighteen of the twenty-five cases. In the photographic version, however, seventeen of the 25 illustrations have means that go up from the fifth grade to the 8th grade but then remain constant or go down from the 8th grade to the 11th grade.

A simple analysis of variance relative to the 5th and 8th grades and again from the 8th to the 11th grades brought out the following information. In the line-versions there is a significant difference between the 5th and the 8th grade at the 5 per cent level for five of the illustrations. Thirteen of the illustrations indicate a significant difference between the 5th and 8th grade in the line-version at the 1 per cent level. Only seven of the illustrations do not have a significant difference between the two grades. But even so all but one of these seven have an upward trend toward the eighth grade.

When comparing the eighth grade with the 11th grade for the line-version, a significant difference at the 5 per cent level was found for three of the illustrations. At the 1 per cent level, two of the illustrations were significantly in favor of the eleventh grade. Of the remaining twenty illustrations, thirteen of them had their mean scores in a trend upward from the 8th to 11th grade. Two of them remained at a plateau and the remaining five moved down slightly.

Looking at the photographic version of the illustrations finds a

somewhat different story. Differences between the 5th and 8th grades were as follows: at the 5 per cent level four illustrations were upward in favor of the 8th grade, and ten of the illustrations were upward in favor of the 8th grade significantly at the 1 per cent level. Of the remaining eleven illustrations without a significant difference between the two grades, all of them indicated an upward trend toward the 8th grade.

When considering the photographic version from the 8th to 11th grade, a totally different direction appears. Four of the illustrations have a significant difference between the 8th and 11th grade in favor of the eigth grade at the 5 per cent level and 1 of the illustrations finds a significant difference in favor of the eighth grade at the 1 per cent level. Of the twenty remaining illustrations having no significant differences between the 8th and 11th grades, five illustrations have tendencies favoring the 11th grade, three of the illustrations have plateaued and the remaining thirteen illustrations move in a direction favoring the 8th grade.

A list of the F-ratios developed from a simple analysis of variance relative to the 5th and 8th grades line-version, 5th and 8th grades photographic version, 8th and 11th grades line-version, 8th and 11th photographic version, and a comparison of photographic version and line-version by grades can be found in Appendix F and G together with an indication of those which are of a significant difference.

CONCLUSION

Conclusions attributable to the data from this investigation can be most easily dealt with through the hypotheses outlined near the beginning of this study. Further comment is also in order relative to the "trends" outlined in the previous section.

Hypothesis No. 1: There is no difference attributable to grade level.

The previous analysis provided ample evidence of differences attributable to grade level. Twenty-four of the twenty-five illustrations showed a significant difference in recognition and comprehension from the fifth through the eleventh grades. In particular, it is generally true for both versions from the fifth to the eighth grade, being significant at the five per cent level or better for eighteen of the twenty-five line-drawing versions and for fourteen of the photographic versions.

Furthermore, the trend of those illustrations not having a significant difference, coincides with the other illustrations. As indicated in the discussion on trends, the means progressed consistently upward for subjects using the line version from the fifth to the eleventh grade. However, the number of these illustrations producing a significantly different number of interpretations decreased to five when the eleventh grade was reached.

The interesting variation from the above pattern appears for subjects in the eighth to the eleventh grades using the photographic version. This would seem to indicate that a change takes place in recognition and interpretation of photographic pictorial stimuli for eleventh graders as opposed to eighth graders. Furthermore, this variation would

imply that the ability to interpret still photographs does not follow the same pattern as the ability of subjects to use line drawings.

There is a suggestion that either pupils reach a maximum growth in ability to interpret photographic illustrations soon after the eighth grade or that a lack of use ensues between these two grades causing the abilities of eleventh graders to plateau or fall off. The latter would appear to be more likely since the interpretive ability falls off in a large majority of the illustrations after the eighth grade at the same time that it drops below the interpretation of line drawings.

Simultaneously it might be inferred that neither of these two forces operate on the growth of pupils' abilities to interpret line drawings. As for the development of greater skill in recognizing and interpreting such drawings, pupils continue to increase in this skill. However, it might be noted that this increase is slowed markedly by the eleventh grade. Again, the explanation of use and disuse may apply to this trend--that line drawings are a greater part of the pupil's study life as he progresses up the scale of grades.

Hypothesis No. 2: There is no difference in results attributable to type of illustration (line drawing and photographic likeness).

Studies and discussions of research cited earlier in this report tended to indicate the value of the line drawing as a more functionally simple surrogate than the photographic still picture. Use of still photographs and line drawings which depict meaningful concepts found in the school's science curriculum as used in this investigation does not support this concept.

In terms of the overall investigation little or no difference developed between picture type. Within grades little indication also exists. Only two mixed differences at the five per cent level appeared for the fifth grade. The two differences at the eighth grade level were in favor of the photographic version, whereas, three differences of significance in favor of the line version developed in the eleventh grade. Out of the twenty-five illustrations this must be considered inconclusive.

The only indicators that might partially support proponents of either type of surrogate as superior to the other would be the trend that developed between the two versions. Though not at significant levels the illustrations' means were predominantly in favor of the photographic version in the 5th grade. This trend reversed itself between the eighth and the eleventh grade, the line version's means being almost always highest.

In fact, this particular trend implies the possible condition of a greater advantage in using photographs in earlier grades and also implies advantages in favor of line drawings in later grades. In any event, such possibilities are only hinted at as possibilities in this investigation.

Hypothesis No. 3: There is no difference attributable to the interaction of type of illustration and grade level.

Six of the twenty-five illustrations indicated an interaction between grade and illustration type that was significant at the five per cent level or greater. The discussion just above regarding dominant trends of picture type within grade level is in itself an impli-

cation of some interaction. Examination of these six illustrations having significant interaction operating produces an unusual fidelity to the trend outlined at the end of the previous hypothesis.

SUMMARY AND IMPLICATIONS

Use of meaningful material, generally found as part of the pupil's school experience, made up the test material of this investigation. Care was taken to use concepts appropriate to static, pictorial presentation. A response system was used that precluded hints at desirable answers. Only minor difficulties developed from rating these responses. Within the scope of this study, then, line drawings and photographs were equally as effective in obtaining correct recognition and interpretation of stimuli found in illustrations. Pupils develop in their skill of interpretation for both line drawings and photographs. However, this development plateaus at the eighth grade level for photographic illustrations and slows in its upward movement by the eleventh grade for the line version.

The trends discussed earlier would indicate that more work perhaps ought to be done to isolate the forces at work here, if any. A different approach to gaining data on recognition of surrogates that deal with meaningful content is certain to bring more results.

At a minimum the implication is clear that something more must be considered or discovered about illustrations that are to be used in the school context, something more than the implication of past research that the simple line drawing is the more efficient, functional surrogate for use with the learner.

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APPENDIX A

Common Science Concepts

1. Magnetic Poles (Bar magnet)
2. Magnetism (Electro magnet)
3. Static Electricity (Electroscope)
4. Circuits (Series light bulb)
5. Batteries
6. Fuse
7. Heat (Convection)
8. Temperature (Freeze-boil) (Thermometer)
9. Expansion of Materials
10. Crystals
11. Astronomy (Eclipse of moon)
12. Big Dipper
13. Lenses
14. Prism
15. Telescope
16. Machines (Gears)
17. Machines (Block & Tackle)
18. Machines (Levers)
19. Sound
20. Tuning Fork
21. The Ear
22. The Eye
23. Measurement of Time
24. Airplane Lift (Bernoulli Principle)
25. Pressure
26. Barometer
27. Jet Engine
28. The Compass
29. Parts of Flower
30. Microscope
31. The living Cell
32. Atoms and Molecules
33. Fossils
34. The Gasoline Engine

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APPENDIX B

Panel Reactions

Below is a compilation of the reactions of a panel of experts when they viewed the original 39 pictures taken for this investigation. Panelists A, B and C are science educators and panelists D and E are media specialists. The only information given the panel members was that these pictures presumably were intended to deal with science. The key to their reactions (in general terms) appears at the top of the table.

REACTION OF PANEL TO ORIGINAL PHOTOS April 1, 1965

OK=TOTAL ACCEPTANCE OK?=ACCEPTANCE WITH ONLY MINOR RESERVATIONS
?=DOUBT USEFULNESS OF PICTURE N=TOTAL REJECTION OF PICTURE

NEG. NO.	DESCRIPTION	PANEL MEMBERS A	B	C	D	E	PICTURES CHOSEN
33	PENCIL IN JAR OF WATER	OK	OK	OK	OK	OK	2
3	GIRL BLOWING ON PAPER	N	N	N	N	N	
23	BATTERY & PARALLEL CIRCUIT	OK	OK	OK	OK	OK	20
39	BALLOONS HANGING APART	OK	OK	N	OK	OK	12
17	EYE DROPPER & COLORED WATER	N	N	?	N	OK	
1	TOMATO--CROSS SECTION	OK	OK	OK	?	N	13
36	PAPER CUTTER	OK	OK	OK	OK	OK	16
34	NUT CRACKER	OK	OK	OK	OK	OK	1
7	SCISSORS	OK	OK	OK	OK	OK	7
31	SINGLE PULLEY	?	N	OK?	OK	OK	
6	DUAL PULLEY	N	N	N	OK	OK	
21	BAR MAGNETS ON STRING	OK	OK	OK	OK	OK	25
14	TREE TRUNK--CROSS SECTION	OK	OK	OK	OK	OK	3
38	DOOR BELL	N	OK	OK?	OK?	N	

NEG. NO.	DESCRIPTION	A	B	C	D	E	PICTURES CHOSEN
18	GIRL, PINGPONG BALL, FUNNEL	OK	OK	OK	OK	OK	11
25	CRYSTAL IN LIQUID	OK?	OK	N	N	N	
22	PAPER CLIP & MAGNET	OK	OK	OK	OK	OK	4
37	MAGNIFYING GLASS, NEWSPAPER	OK	OK	OK	OK	OK	9
19	COMB & PAPER STRIPS	OK	OK	OK	OK	OK	8
5	BAGS & CANDLE	N	OK	N?	OK	OK?	
10	MAGNETIC FIELD, IRON FILINGS	OK	OK	OK	OK	OK	15
13	FLOWER (MEDIUM SIZE)	OK(1)	OK(2)	OK(1)	OK(1)	OK(2)	10
9	FLOWER (CLOSE-UP)	OK(2)	OK(1)	OK(2)	OK(2)	OK(1)	
12	FLOWER (LONG SHOT)	OK?	OK(3)	N	OK(3)	OK(3)	
35	APPLES ON STRING	?	OK	OK?	OK	OK	14
30	TEST TUBE IN BEAKER	N	N	N	OK	OK	
4	BATTERY--CROSS SECTION	OK	OK	OK	OK	OK	23
16	SPRAY CAN WITH SPRAY	OK	OK	OK	OK	OK	6
15	APPLE--CROSS SECTION	OK	OK	OK	OK	OK	5
24	GLASSES ON GIRL	N	OK	OK	OK	N	18
8	SCALE & WEIGHTS	OK	OK	OK	OK	N	17
39	TUNING FORK	N	OK	N	OK	?	
26	DILATED EYES	N	N	N	N	N	
28	PLUG IN OUTLET	OK	OK	OK	?	N	24
27	MEGAPHONE	N	OK	N	OK	N	
20	WINDEX BOTTLE	OK	OK	N	N	OK	

APPENDIX C

Pictorial Stimuli

Line Version **Photographic Version**

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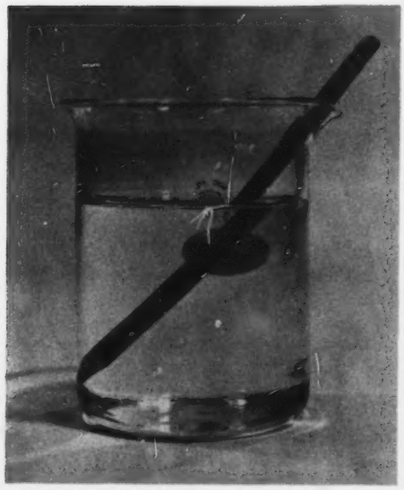
-2-



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Photographic Version

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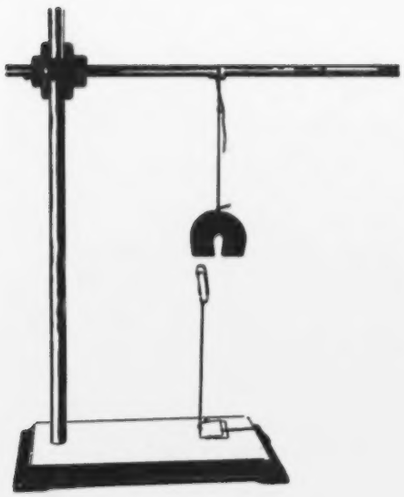

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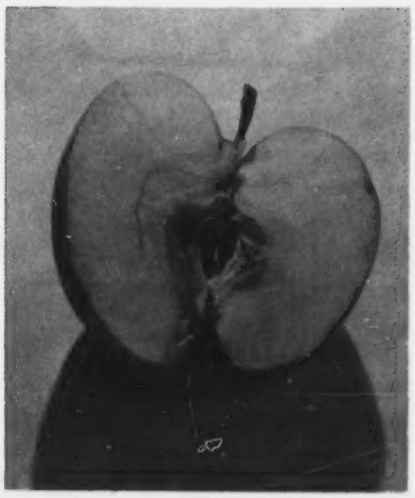

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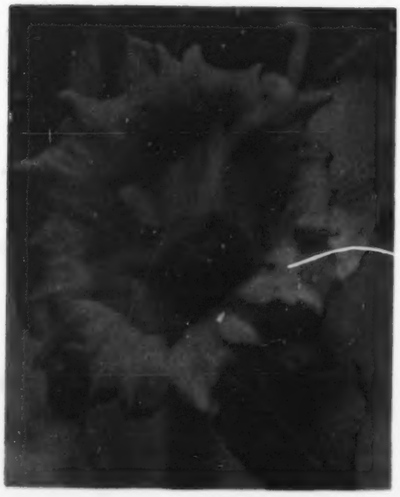

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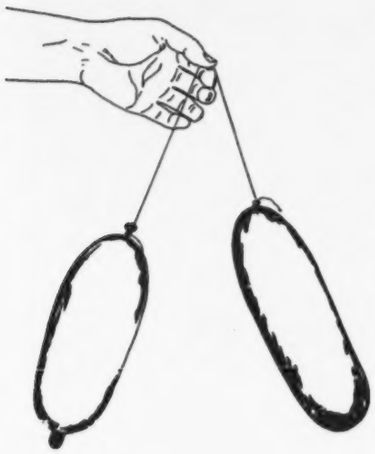

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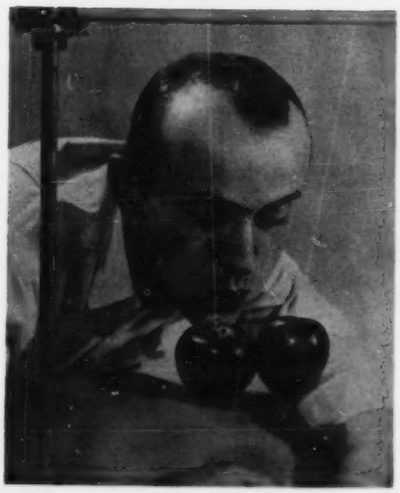

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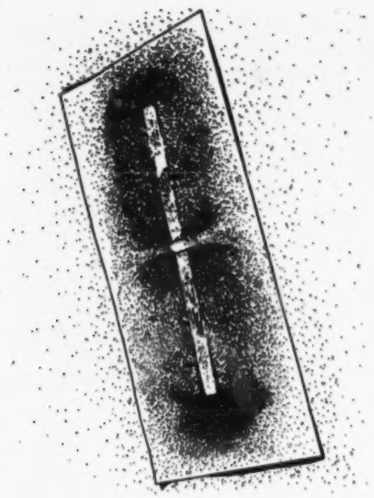

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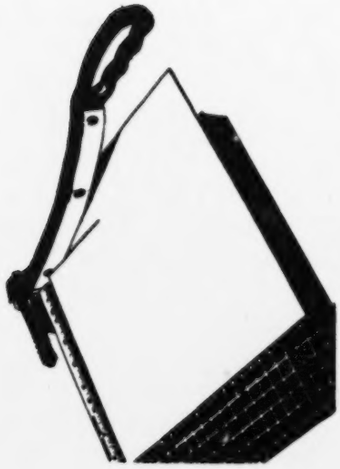

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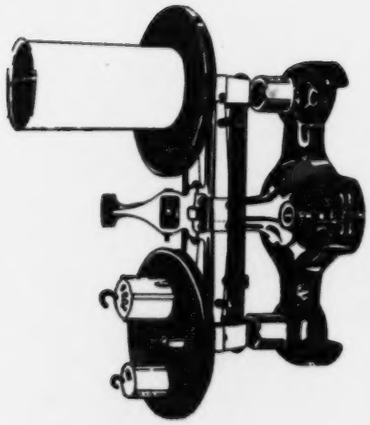

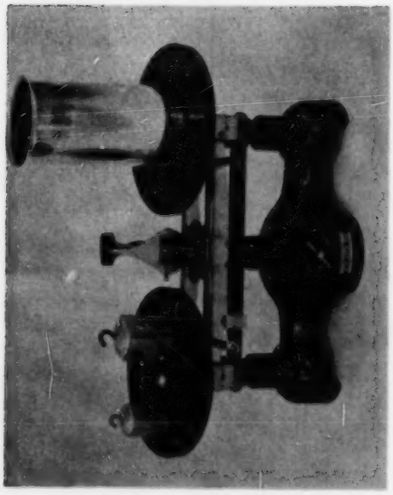

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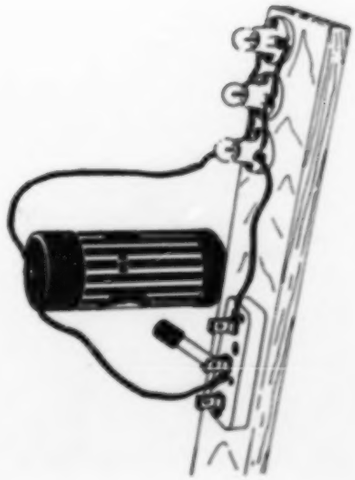

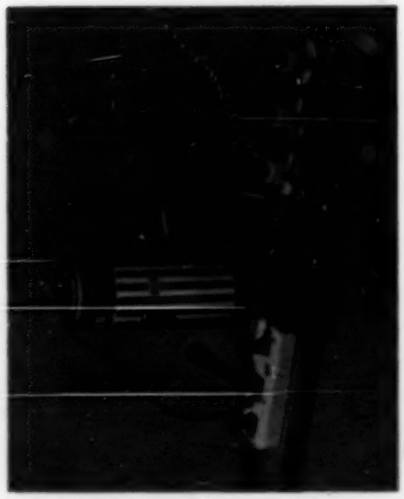

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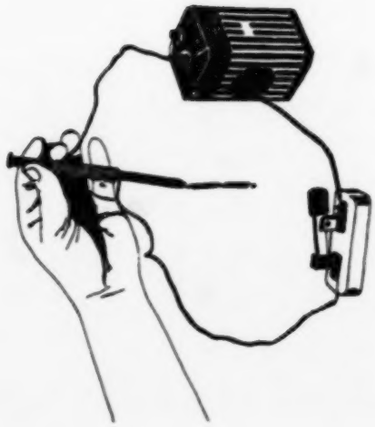

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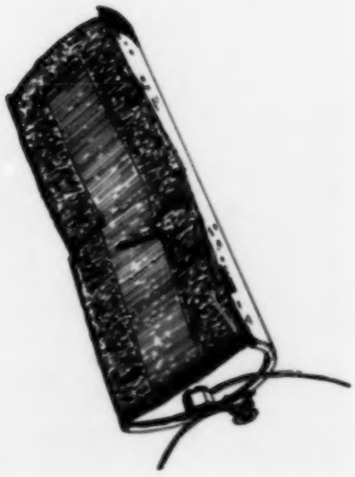

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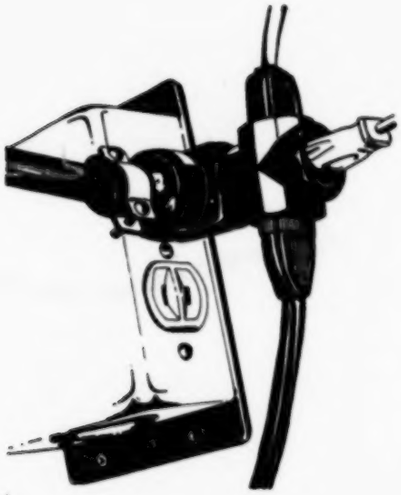

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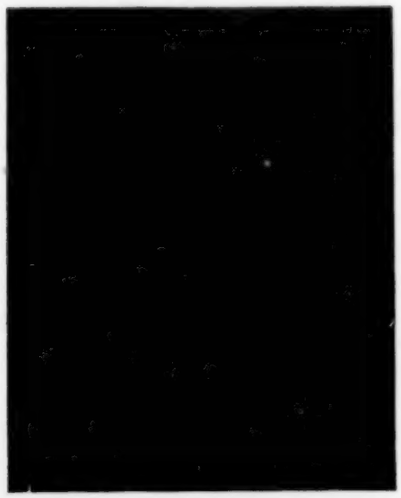

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APPENDIX D

RESPONSE BOOKLET
STILL PICTURE RECOGNITION PROJECT

NUMBER OF PICTURE NOTEBOOK_____

GRADE_____

BOY_____ GIRL_____

CITY_____

INSTRUCTIONS: In this booklet you have numbers which refer to numbered pictures in the "Experimental Science Pictures" booklet. After you have been given the Picture Booklet, fill in the blanks above. Then read the rest of these instructions.

Do Not look at any pictures until you are told to begin.

In the Picture Booklet you will find pictures that you are to identify and describe in this Response Booklet. First, please tell us what things you see in the picture by writing it onto the two lines after the picture's number. Secondly, write onto the next two lines any science idea, concept or principle that you see in that picture. If you do not see any science idea in that picture, just write the word "none."

Remember, there are no right or wrong answers. Any response you feel is right is the correct thing to write in this booklet.

1.

After each of the numbers below tell what you see in the picture of that number. If you recognize an idea having to do with science, briefly tell us what scientific idea, principle or concept you see in that picture.

1. Things you see:_____ 1.

_____

Science idea, if any:_____

_____

2. Things you see:_____ 2.

_____

Science idea, if any:_____

_____

3. Things you see:_____ 3.

_____

Science idea, if any:_____

4. Things you see:_____ 4.

_____

Science idea, if any:_____

_____

5. Things you see:_____ 5.

_____

Science idea, if any:_____

_____

APPENDIX E

Judges Criteria

PENNSYLVANIA STATE UNIVERSITY
OE STILL PICTURE PROJECT #5096

Criteria for judging student responses to science pictures

USE THE NUMBER WHICH PRECEDES THE APPROPRIATE CATEGORY AS THE RATING FOR A GIVEN RESPONSE. THE RESPONSE:

1. Generally does not recognize "things" (items--most of the parts) in the picture nor does it indicate any understanding of the science concept involved.

2. Generally does recognize the "things" (items--most of the parts) in the picture but does not indicate correct understanding of the science concept involved.

3. Does indicate a general understanding of the science concept involved but does not go beyond a description of the pictured concept.

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APPENDIX F

F-Ratio--Photo vs. Line--Within Grades

* Significant at .05 level

** Significant at .01 level

P Photo

L Line

Illustration	5th Grade	8th Grade	11th Grade
1	.49	2.50	4.04*L
2	.75	.95	.80
3	.06	.11	1.40
4	.16	4.23*P	.80
5	4.79*L	.01	1.11
6	.36	.02	3.68
7	2.99	1.61	5.86*L
8	2.08	1.64	.93
9	.28	1.91	.49
10	.06	1.21	1.15
11	4.80*P	18.93**P	.74
12	1.53	3.17	.26
13	1.05	.44	.57
14	1.77	.57	1.83
15	1.77	.30	4.23*L
16	1.77	1.67	.01
17	.01	.01	1.05
18	2.26	.22	.08
19	2.01	.88	1.30
20	3.28	.01	.57
21	.09	.01	1.87
22	.01	.26	2.36
23	3.47	.99	.07
24	.11	.07	.01
25	.88	.21	1.26

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APPENDIX G

F-Ratio--Adjacent Grades--Within Version

* Significant at .05 level

** Significant at .01 level or better

D = Mean goes down from 8th to 11th Grade

Illustrations	5th to 8th Grade Line	5th to 8th Grade Photo	8th to 11th Grade Line	8th to 11th Grade Photo
1	.49	2.71	6.76*	.84 D
2	2.64	4.14*	.79	1.64
3	3.09	4.03*	4.08*	.29
4	1.31	13.55**	2.67	1.91 D
5	.10	3.76	3.29	.51
6	7.70**	4.07*	.34	1.14 D
7	.21	.02	6.00*	.96 D
8	19.88**	27.46**	.09	3.90*D
9	.80	3.45	.42	2.16 D
10	1.27	8.88**	4.49*	.01
11	1.54	10.28**	9.96**	.06 D
12	5.80*	17.39**	.26	4.20*D
13	.46	.46	.00	.01
14	6.30*	2.98	.41	1.85 D
15	34.92**	28.88**	1.36	.00
16	3.84	3.99*	1.07	.09 D
17	11.08**	15.01**	.01	.70
18	5.43*	1.93	.79	.04
19	7.25**	6.73**	.48	1.86 D
20	16.76**	8.56**	1.57 D	5.92*D
21	4.48*	6.42*	.92	.05 D
22	9.34**	15.55**	.32 D	7.76**D
23	24.67**	6.82*	.17 D	.28
24	10.06**	15.67**	.30 D	.71 D
25	26.10**	17.07**	1.95 D	4.02*D